Aquaponics

HORT 4601

University of Minnesota
Driven to Discover℠

Comparing Multiple Forms of Light on Different Cultivars of Swiss Chard in an Ebb and Flow Bench Aquaponics System

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Project Goals

- Identify the most efficient light sources by comparison in the same aquaponic system
- Identify the most productive Swiss Chard cultivar, between 'Lucullus' and 'Bright Lights' in an ebb and flow system as measured by plant productivity
- Provide commercial and hobby producers with research for the most efficient production systems.

Introduction

- Aquaponics: Production of plant and aquatic animal products in a closed loop system. Recently aquaponics has become popular due to potential sustainable aspects (Bernstein 2011).
- Current studies suggest a need for supplemental lighting and recognition of additional cost to the production system (Diessner 2013).
- Many supplemental light options: LED, HID, Fluorescent
- Both large and small scale growers benefit from this study's attempt to quantify the inputs, costs, benefits, and drawbacks associated with different types of light.
- *Beta vulargis,* Swiss Chard
  - Two cultivars 'Bright Lights' and 'Lucullus'
  - Tolerant of many growing conditions
  - Quick germination and time to maturity

Methods

- To properly study the variables selected, supplemental light and specific cultivar of swiss chard, our group used an Ebb and Flow design aquaponics system. Figure 1 to the right shows the system layout.
- The two cultivars used in this study; 'Bright Lights' and 'Lucullus' were grown under three different supplemental light treatments; High Intensity Discharge and two separate LED systems.
- Once at maturity, mature leaves were harvested off of plants. These leaves were measured for wet & dry weights and leaf area. After the final harvest, the total productivity of each plant was formulated.

Figure 1: Ebb and Flow System

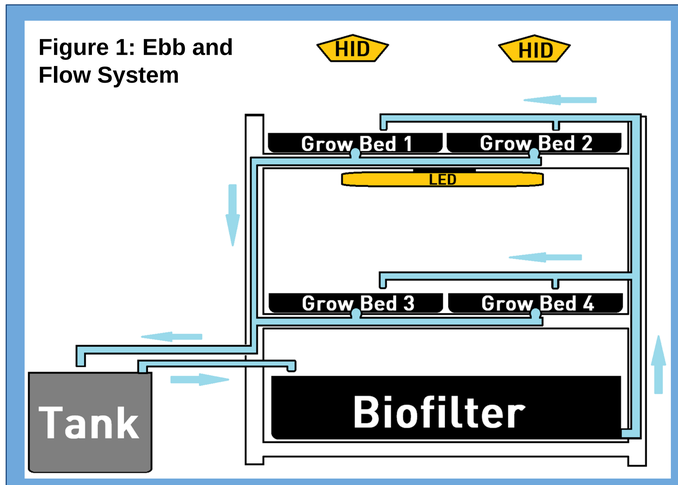


Table 1: Summary of Light Cost Analysis

System	Optimal Sunlight PAR	Cloudy Sunlight PAR	Optimal Sunlight Daily mol/m²	Cloudy Sunlight Daily mol/m²	Optimal Sunlight Cost/m² (Plant)	Cloudy Sunlight Cost /m² (Plant)
Shelf 1A Sun & HID	550 µmol m^{-2} s^{-1}	195 µmol m^{-2} s^{-1}	316.6 mol/m² ★	112.32 mol/m²	$0.00/m² ($0.00) ★	$1.60/m² ($0.013) ⊘
Shelf 2A GrowPan	375 µmol m^{-2} s^{-1}	375 µmol m^{-2} s^{-1}	216 mol/m²	216 mol/m² ☆	$0.259/m² ($0.002)	$0.259/m² ($0.002) ☆
Shelf 2B LightStrip	60 µmol m^{-2} s^{-1}	60 µmol m^{-2} s^{-1}	34.56 mol/m² ⊘	34.56 mol/m² ⊘	$0.041/m² ($0.0003)	$0.041/m² ($0.0003)

Photos: Ebb and Flow Shelf-ponics systems (top right), multi-harvested bright-lights swiss chard planted in rockwool (top left), and LED GrowPan light fixture (center left).

Figure 2: Weekly Harvest (g) per plant

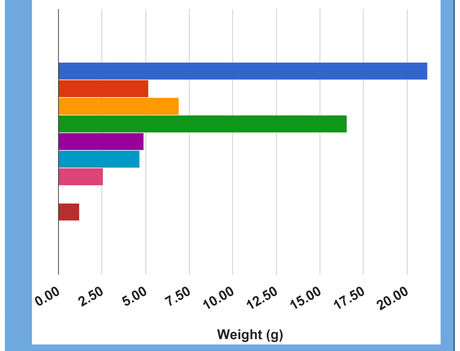


Figure 3: Total Leaf Area per Plant (cm^2)

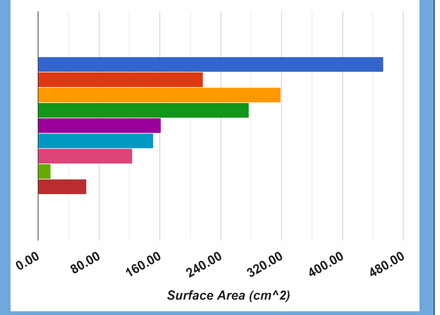
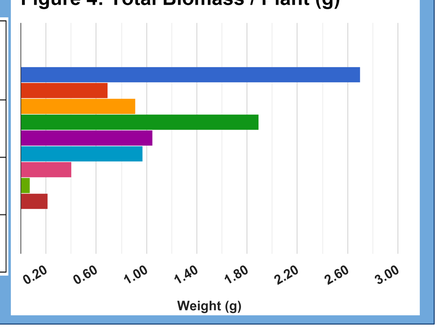


Figure 4: Total Biomass / Plant (g)



Results & Discussion

- Ranking of light fixtures (least to most expensive):
  - -HID/supplemental
  - -LED LightStrip
  - -LED GrowPan
- **Table 1** demonstrates **LED fixtures are most efficient at providing plants with usable light**(PAR, mol/day) per watt than conventional HID or fluorescent lighting, but LED fixtures cost significantly more.
- Lower shelves of the system received almost all light from the LED fixtures.
- On the to shelf Light was supplemented after reaching a natural light threshold less than 200 µmol m^{-2} s^{-1}.
- **The top shelf was the best performer under natural sunlight with HID supplemental light**.
- Shelf 2A LED GrowPan was the second best performer under optimal light conditions.
- Shelf 2B LightStrips was last.
- **Differences between cultivars were significant when leaf area and fresh weight were measured.** This was supported by ANOVA tests resulting in p-values for leaf area and fresh weight being *p*=0.08 and *p*= 0.03 respectively.
- **Final biomass of each cultivar was not shown to be statistically different** indicated by an *p*=0.39.
- **Fresh weight and leaf area are of higher concern than biomass in aquaponics systems** where plants are often sold fresh.
- **'Lucullus' grown in this ebb and flow system resulted in largest leaf area and fresh weight between cultivars.**
- **Figure 3** shows the increased fresh weight of 'Lucullus' over each treatment in comparison to 'Bright Lights' 2.

Recommendations

- In this aquaponics system the **'Lucullus' Swiss Chard cultivar was most productive** in producing leaf area and fresh weight
- **Natural light with supplemental HID was most effective** as producing plant leaf area, fresh weight and biomass
- The **most cost efficient type** of light in terms of daily plant usable light was the **LED GrowPan**
- Further study should factor in outside environmental effects on greenhouse production, ie. cloudy days.

Acknowledgements

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Sources

Diessner, C. G. (2013). Small scale raft aquaponics: Evaluation of hybrid striped bass growth and plant uptake potential (Doctoral dissertation, University of New Hampshire).
All Figures/Pictures developed by our research group